FreedomCAR Technology

Just the Basics: HYDROGEN

Hydrogen is a sustainable, non-polluting source of power that can be used in mobile and stationary applications. It is an ideal energy carrier that helps to increase our energy diversity and security, by reducing our dependence on hydrocarbon-based fuels.

What Makes Hydrogen so Useful for Energy Production?

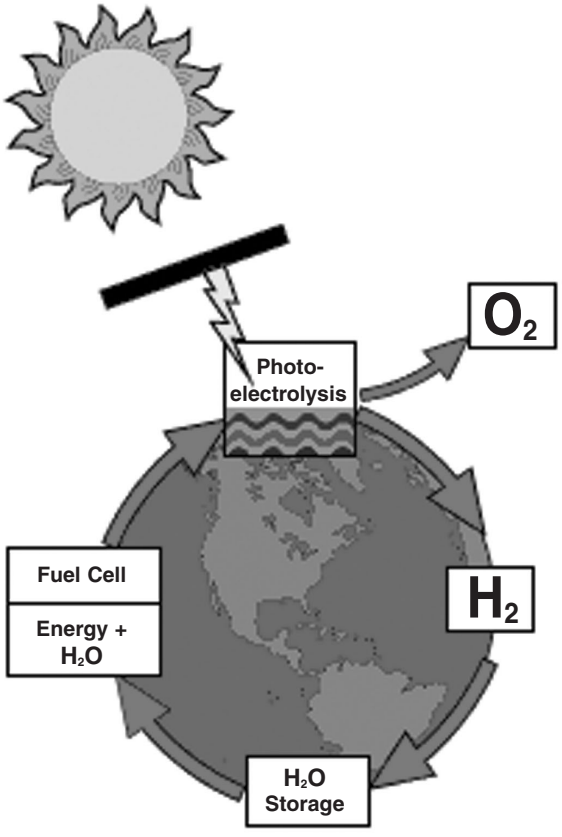
Hydrogen is the simplest element and most plentiful gas in the universe. Yet hydrogen never occurs by itself in nature — it always combines with other elements such as oxygen and carbon. Once it has been separated, hydrogen is the ultimate clean-energy carrier. How clean? Clean enough that the U.S. Space Shuttle program relies on hydrogen-powered fuel cells to operate shuttle electrical systems, and the crews drink one of the byproducts: pure water!

Hydrogen is an obvious alternative to hydrocarbon fuels, such as gasoline. It has many potential uses, is safe to manufacture, and is environmentally friendly. Today many technologies exist that can use hydrogen to power cars, trucks, electrical plants, and buildings – yet the absence of an infrastructure for producing, transporting, and storing large quantities of hydrogen prevents its practical use.

How is Hydrogen Produced?

Most methods of producing hydrogen involve splitting water (H_2O) into its component parts of hydrogen (H_2) and oxygen (O). The most common method involves steam reforming of methane (from natural gas), although there are several other methods, too.

- *Steam reforming* converts methane (and other hydrocarbons in natural gas) into hydrogen and carbon monoxide by reaction with steam over a nickel catalyst
- *Electrolysis* uses electrical current to split water into hydrogen at the cathode (+) and oxygen at the anode (-)
- *Steam electrolysis* (a variation on conventional electrolysis) uses heat, instead of electricity, to provide some of the energy needed to split water, making the process more energy efficient



When hydrogen is generated from renewable sources, its production and use can be part of a clean, natural cycle.

- *Thermochemical water splitting* uses chemicals and heat in multiple steps to split water into its component parts
- *Photolysis (photoelectrochemical)* uses sunlight and catalysts to split water
- *Biological and photobiological water splitting* use sunlight and biological organisms to split water
- *Thermal water splitting* uses a very high temperature (approximately 1000°C) to split water
- *Biomass gasification* uses selected microbes to break down a variety of biomass feedstocks into hydrogen

What's Preventing Wide-Scale Hydrogen Production Today?

Cost is the biggest impediment to using hydrogen more widely as a fuel. Many expensive changes must be made in our nation's energy infrastructure to accommodate hydrogen. For example, electricity is required by many hydrogen production methods, which overall costs and makes hydrogen more expensive than the fuels it would replace.

Another concern is hydrogen's flammability – it can ignite in low concentrations. That means leaks in transport and storage equipment could present public safety hazards. These facts don't preclude transporting and storing hydrogen, but they do highlight some of the many practical considerations to be addressed before wide-scale use of hydrogen becomes a reality.

Meanwhile, researchers are developing new technologies that can use hydrogen that is stored or produced, as needed, onboard vehicles. These technologies include:

- Hydrogen internal combustion engines, which convert hydrogen's chemical energy to electricity using a hydrogen piston engine coupled to a generator in a hybrid-electric vehicle
- Onboard reforming for fuel cells, which uses catalytic reactions to convert conventional hydrocarbon fuels, such as gasoline or methanol, into hydrogen that fuel cells use to produce electricity to power vehicles

Driving Toward a Hydrogen-Based Energy System

With the announcement of the FreedomCAR Partnership to develop fuel-cell-powered vehicles, the U.S. Department of Energy has committed to advancing toward a hydrogen-based energy system and making fuel-cell-powered vehicles available by 2010. This commitment will spur development of the technologies needed to make hydrogen-powered transportation a reality.

For further information, contact:

Peter Devlin
U.S. Department of Energy
202-586-4905
peter.devlin@ee.doe.gov